and quantitative measurements of articular cartilage degeneration. MR imaging of OA animal models enable detection of early pathological changes, track disease progression and test suitable drugs for OA. The purpose of this study was to use high-resolution in vivo MRI with advanced quantitative imaging techniques to determine longitudinal changes in articular cartilage in a small animal model of post-traumatic OA.

Methods: Twelve male Wistar Rats, mean age 12 weeks at the start of the experiment, were randomized to either the surgical intervention group (OA) or sham surgery group. The OA group rats ($n = 6$) underwent anterior cruciate ligament transection (ACLT) surgery. Each rat was anesthetized with isoflurane and the ACL was transected with sterile micro-scissors in the right knee joint. After surgery, the joint surface was washed with sterile saline solution, and both capsule and skin was sutured. In the control group ($n = 6$), the rats underwent a sham surgery in which the right knee joint was exposed, and then closed after saline washing. All the rats underwent MRI of the knee joint at 3, 6 and 12 weeks after surgery on a 7T 300 MHz horizontal bore Varian MR system, using a dedicated 63 mm volume transmit coil with a 20 mm diameter surface receive coil. Quantitative T1ρ, T2, and T2* images which allow for creation of T1ρ, T2, and T2* maps during post-processing were acquired. Cartilage was segmented semiautomatically into the following compartments: lateral femoral condyle (LFC), medial femoral condyle (MFC), lateral tibia (LT) and medial tibia (MT). T1ρ, T2 and T2* relaxation times were determined in those regions of interest to evaluate changes in articular cartilage at different time points.

Results: Representative morphological images of the knee joint with T1ρ, T2 and T2* colour map overlays are shown in Fig.1. Higher T1ρ, T2 and T2* values were observed in the knee joints of OA group rats compared to the control group. At 3 weeks, T1ρ values were significantly higher in the LFC, MT and LT compartments in the OA group (35 ± 7, 24 ± 4, 32 ± 7 ms respectively, $p < 0.05$) compared to the control group (22 ± 4, 17 ± 2, 20 ± 6 ms respectively). T2 values of the OA group were significantly higher in the MFC and MT (31 ± 5, 23 ± 4 ms respectively, $p < 0.05$) compared to the control group (19 ± 1, 17 ± 2 respectively) at 3 weeks after ACLT surgery. The values were also high at week 3 compared to 12 weeks in the OA group ($p < 0.05$ for MFC). No significant differences in T1ρ, T2 and T2* values were observed over time in the control group.

Conclusions: We have demonstrated in this study that T1ρ, T2 and T2* relaxation times were sensitive to early changes in cartilage induced by ACL transection in a rat model. Higher T1ρ, T2 and T2* values in OA group indicates loss of proteoglycans, collagen and hydration changes at 3 weeks after surgery. Our data suggest cartilage degradation observed after ACLT in this animal model mimics the early stage OA due to biochemical disruption in the cartilage extracellular matrix. These findings suggest that quantitative MR imaging biomarkers are an invaluable tool to measure early articular cartilage compositional changes in the knee joint of traumatic OA. Evaluation of the longitudinal changes in the subchondral bone compartment in this animal model will provide further insight into the pathological changes during the progression of OA.

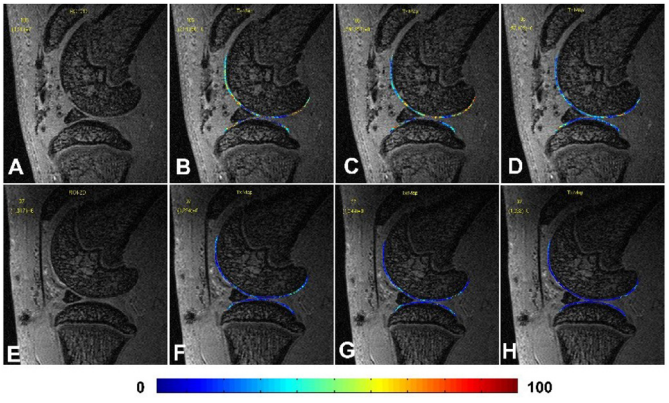

Fig. 1. Representative T1ρ (B), T2 (C) and T2* (D) maps of ACL-transected knee and the sham-operated knee (F, G and H) at 3 weeks after surgery, Maps are overlaid on Multi Gradient Echo images.

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IS PATELLOFEMORAL ALIGNMENT AND MORPHOLOGY RELATED TO PATELLOFEMORAL OSTEOARTHRITIS AS EARLY AS ONE YEAR AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION?

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Purpose: Over two million anterior cruciate ligament (ACL) injuries occur annually worldwide, with about half undergoing reconstruction (ACLR). ACLR is associated with patellofemoral osteoarthritis (PF OA) incidence rates ranging from 10 to 90% within 20 years of ACLR. Risk factors for early-onset PF OA following ACLR are poorly understood, though PF alignment and morphology are potentially important in that they are associated with PF OA, pain and function in non-ACLR populations. This may be pertinent as altered knee biomechanics following ACL injury can persist following ACLR and may thus contribute to altered PF alignment. Therefore, our aim was to investigate the relationships between measures of PF alignment and morphology with presence of radiographic OA, patient reported outcomes (PROs) and function one year following ACLR.

Methods: We assessed 118 participants, aged 18–50, one year after primary ACLR (single-bundle hamstring tendon autograft) in Melbourne, Australia (surgery between July 2010 & August 2011). Participants were excluded if they had follow-up surgery or any other condition affecting function. Using 3T MR images with PD 3D VISTA sequencing, we measured alignment (lateral displacement [LD], patellar tilt angle [PTA], Insall-Salvati Ratio [ISR], patellar-trochlear index [PTI]) and morphology (lateral trochlear inclination [LTI], sulcus angle [SA]) of the reconstructed knee. Intra-rater reliability was obtained for all six measures. Dependent outcomes were PF OA (Kellgren & Lawrence grade ≥ 2, using lateral & skyline radiographs); two PROs (Anterior Knee Pain Scale [AKPS], Knee injury and Osteoarthritis Outcome Score [KOOS]); and four functional tests (single leg hop distance, triple crossover hop, side hop, one leg rise). Outcomes were assessed as continuous and binary using previously established cut-points where available. Linear and logistic regression models were proposed with sex, age, BMI and frontal plane alignment (valgus vs. varus with 0 cut-point) considered using manual backwards selection. Significance was set at $p < 0.05$.

Results: Complete image analysis was available for 112 participants (2 excluded with poor image quality, 4 had no PD 3D VISTA images). The full cohort included 76 men (64%) and 42 women (36%). Mean age at surgery was 30 years (range 18–50). Mean BMI was 26.0 kg/m^2 (18.7–37.4). Of the full cohort, 24 (20%) had PF OA of the ACLR knee vs. 8 (7%) on the unaffected knee (McNemar test $p < 0.01$). *PF OA:* ACLR knees with patella alta (ISR > 1.2) had higher proportions of PF OA vs. those without (X^2 test $p = 0.03$). Logistic regression modeling revealed no other alignment measures were associated with PF OA. Shallower trochlear groove (higher SA [$p = 0.04$]; lower LTI [$p = 0.03$]) was more likely to be associated with PF OA. *PROs:* Linear regression models revealed greater PF cartilage overlap (higher PTI) was associated with worse scores on the AKPS ($p = 0.05$) and KOOS-Pain subscale ($p = 0.01$); and greater lateral patellar tilt (higher PTA) correlated with lower KOOS-Symptoms subscale scores (p-0.02). *Function:* Linear regression showed greater displacement (LD) was associated with lower function (hop distance [$p = 0.05$], triple crossover [$p = 0.04$]), as was larger SA (fewer one leg rises, $p = 0.04$).

Conclusions: Insall-Salvati Ratio as well as lateral trochlear inclination and sulcus angle were significantly related to PF OA one year following ACLR. ISR is the only measure with established cut-points defining abnormal, thus it is possible that similar cut-points for other measures might reveal relationships with PF OA whereas continuous data do not. Overall, PF alignment and morphology were associated with PF OA, PROs, and function. Longitudinal follow-up will confirm whether PF alignment and morphology predicts onset or progression of PF OA and associated functional decline following ACLR.